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Biofluorescence in the herpetofauna of northeast Bangladesh

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Abstract

Fluorescence is a poorly documented phenomenon in vertebrates and has been suggested to play several biological roles. With increased study, the number of species in which biofluorescence has been identified is increasing steadily. We conducted a UV light survey for biofluorescence in the herpetofauna in Lawachara National Park, Bangladesh and found biofluorescence in one amphibian (*Microhyla berdmorei*) and three reptile species (*Boiga cyanea*, *Cyrtodactylus tripuraensis* and *Hemidactylus platyurus*).

Key Words

Amphibia, fluorescent animal, Lawachara, Reptilia, ultraviolet

Introduction

Biofluorescence occurs in living organisms when high energy light wavelengths (e.g. UV or blue light, wavelengths ranging from 10–500 nm) are absorbed and re-emitted at lower energy, resulting in fluorescent light (Shimomura et al. 1962; Kumagai et al. 2013; Marshall and Johsen 2017; Lamb and Davis 2020). Biofluorescence is very common in marine ecosystems and, recently, it has been documented in many terrestrial vertebrates including amphibians, reptiles, birds and mammals (Pearn et al. 2001; Weidensaul et al. 2011; Gruber and Sparks 2015; Taboada et al. 2017a, 2017b; Anich et al. 2020; Lamb and Davis 2020; Top et al. 2020). Vertebrates, broadly, have two types of photoreceptor cells, commonly known as rods and cones. In addition, amphibians have four classes of photoreceptors that confer visual perception and acuity under low light (Mohun and Davies 2019). Of particular importance is the double-cone LWS (low wavelength sensitive) system that can detect either UV light or blue light (Mohun and Davies 2019). Features of this photoreception system resemble those of geckos and nocturnal birds, such as owls (Mohun and Davies 2019). These systems could provide both achromatic visual perception under low light conditions as well as colour discrimination using biofluorescence (Taboada et al. 2017a; Mohun and Davies 2019; Lamb and Davis 2020).

The mechanisms producing biofluorescence vary and can involve proteins, pigments, metabolites or mineralisation (Prötzel et al. 2018; Goutte et al. 2019; Kohler et al. 2019; Park et al. 2019; Prötzel et al. 2021), but in most lineages of animals, the exact mechanisms are unknown (Taboada et al. 2017a, 2017b; Lamb and Davis 2020). Hypothesised functions for biofluorescence include photo-protection, UV light detection, prey or pollinator attraction, male-male interactions, sexual selection, camouflage and improved visual acuity (Salih et al. 2000; Andrews et al. 2007; Kloock et al. 2010; Haddock and Dunn 2015; Macel et al. 2020). In some lineages, the function of biofluorescence is still unknown (Marshall and Johnsen 2017).

The global geographic distribution of biofluorescence is of limited coverage, with widely different species occupying diverse ecosystem types covered in studies on specific taxa. These studies have included mammals in North America and Australia (Kohler et al. 2019; Anich et al. 2021), reptiles in Sri Lanka, Madagascar, southern Africa and the Solomon Islands (Gruber and Sparks 2015; Prötzel et al. 2018, 2021; Mendyk 2021) and amphibians in North and South America (Lamb and Davis 2000; Taboada et al. 2017a; Goutte et al. 2019). Thus, the occurrence of biofluorescence in vertebrates, in general and amongst amphibians and reptiles, in particular, remains poorly studied (Taboada et al. 2017a, 2017b; Thompson et al. 2019; Lamb and Davis 2020; Mendyk 2021). In this study we conducted a survey of biofluorescent herpetofauna in a semi-evergreen forest patch of Bangladesh.

Materials and methods

We conducted the study in Lawachara National Park, a mixed-evergreen forest covering 1,250 ha in northeast Bangladesh. The topography of the forest is diverse, with hills, slopes, streams and small water bodies (Hakim et al. 2020). This small forest patch hosts a high herpetofaunal diversity, with a total of 20 amphibian species and 51 reptile species recorded to date (Al-Razi et al. 2018, 2020, 2021; Hakim et al. 2020). We assessed fluorescence in all amphibian and reptile species we encountered from April 2021 to June 2021. We used a UV torch with 395 nm wavelength. Three members of the team walked along established trails and streams after sunset (from 1900 h to 2200 h) and searched for amphibians and reptiles using headlamps for 14 nights. Once detected, we captured each specimen with minimal disturbance and exposed it to UV light from all sides of its body. We collected information on the presence or absence of fluorescence, including colour, shape and location of the fluorescent body parts. Additionally, we classified animals by age (adult or juvenile) and sex, if possible. The animals were also photographed with a Nikon Coolpix P900 Compact Digital Camera under UV and normal light. We did not use any filter on the light or on the camera lens during photography. We captured 19 species, including 11 species of amphibians (*Leptobrachium sylheticum*, *Kaloula pulchra*, *Microhyla berdmorei*, *Microhyla mymensinghensis*, *Micryletta aishani*, *Minervarya* sp., *Hydrophylax leptoglossa*, *Chirixalus doriae*, *Polypedates teraiensis*, *Raorchestes rezakhani* and *Rhacophorus bipunctatus*) and eight species of reptiles (*Cyrtodactylus tripuraensis*, *Hemidactylus frenatus*, *Hemidactylus platyurus*, *Eutropis macularia*, *Sphenomorphus maculatus*, *Calotes versicolor*, *Ptyctolaemus gularis* and *Boiga cyanea*). We did not assess fluorescence in the genus *Minervarya* at the species level as they are difficult to identify in the field (Sanchez et al. 2018). We released the animals at the exact location where they were found after they were tested. Research work was conducted under the Bangladesh Forest Department permit (permit no: FD 22.01.0000.101.23.2021.1354).

Results

This is the first study that documents fluorescence in amphibians and reptiles in Bangladesh. We recorded fluorescence in one amphibian and three reptile species, namely *Microhyla berdmorei*, *Hemidactylus paltyurus*, *Cyrtodactylus tripuraensis* and *Boiga cyanea.*

Microhyla berdmorei (Blyth, 1856)

Microhyla berdmorei was the only biofluorescent amphibian recorded in this study. We found the fluorescence mainly on the ventral side and on a small portion of the lateral side of its body. Under white light illumination, the colour of the ventral and lateral side appeared yellow to pale yellow, but under the UV light, we found a "bright neon yellow" on the ventral lower abdominal region and limbs (Fig. 1). In addition, the lateral side produced a deep neon yellow colour (Fig. 1). We exposed two males and one female to UV light and the pattern of fluorescence was the same in all the individuals.

Hemidactylus platyurus (Schneider, 1792)

The Flat-Tailed House Gecko, *Hemidactylus platyurus*, was the species with the highest number of biofluorescent individuals in our study (Hakim et al. 2020). Under normal LED light, the colour of the ventral side of the head was pale white, but under the UV light, we found a glowing blue colour aligned with the lower jaw bone (Fig. 2). We applied UV on two adults, one sub-adult and a juvenile and found more pronounced fluorescence in the juvenile compared to the adults and sub-adults. Although fluorescence has been reported in interstitial tissues between the skin and lymph sacs (Taboada et al. 2017a), we did not observe this in *H. platyurus*.

Cyrtodactylus tripuraensis (Mahony et al., 2018)

Fluorescence was previously reported in *Cyrtodactylus* genus (Top et al. 2020). Fluorescence was also present in *Cyrtodactylus tripuraensis* (Tripura Bent-Toed Gecko). The individual was blue under the UV light on both dorsal and ventral surfaces (Fig. 2D–F). The colour of the ventral side of the species is whitish under normal light, but under UV light, the lower jaw bone produced

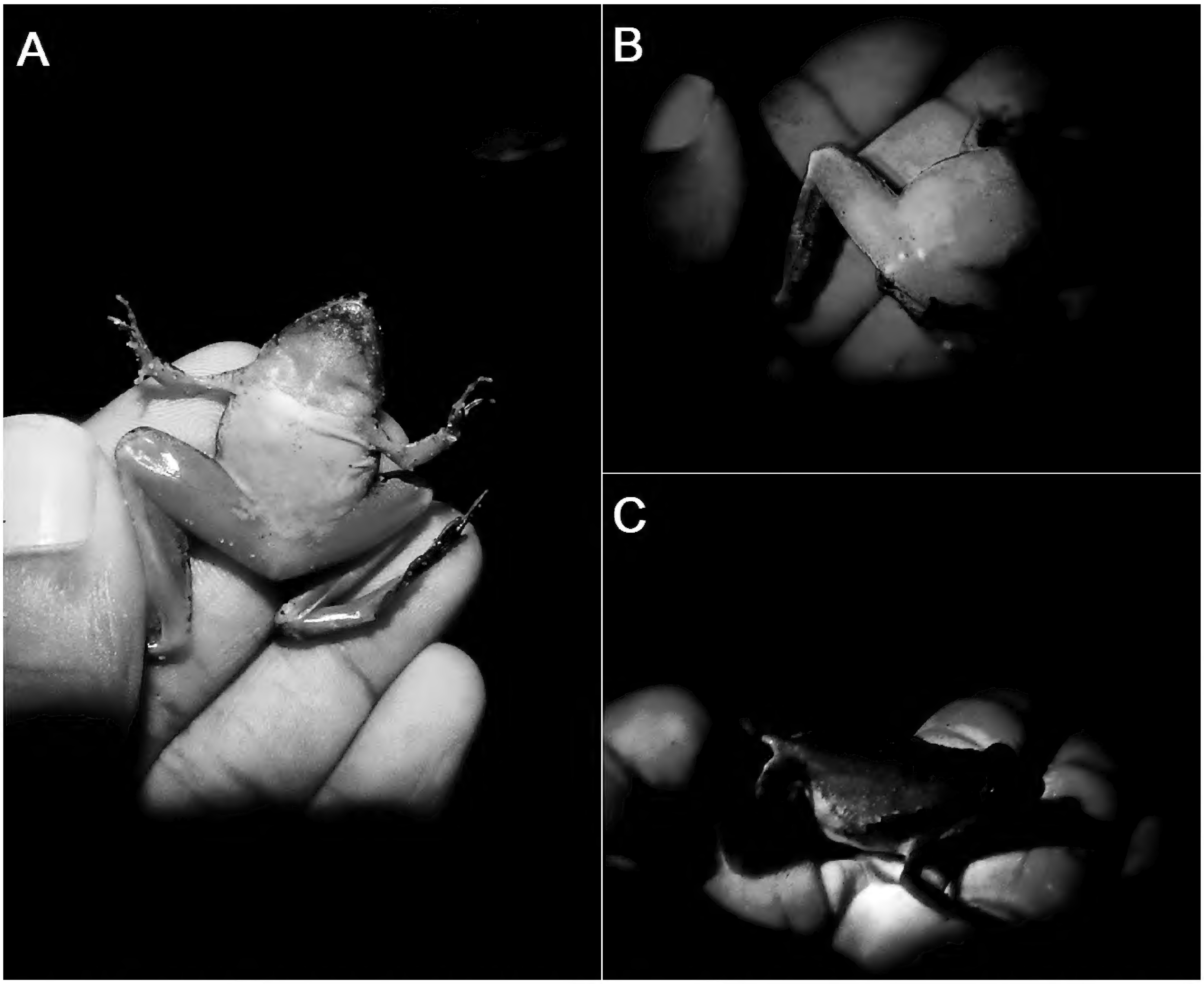

Figure 1. A. Ventral side of *Microhyla berdmorei* under white light. **B.** Neon yellow light is coming from ventral lower abdominal region of *Microhyla berdmorei* in UV light. **C.** Under UV light intense, neon yellow colour is seen in the lateral portion of *Microhyla berdmorei*.

a very prominent blue colour (Fig. 2D). In addition, two obliques areas near the throat (corresponding to the hyoid bones) and scattered areas near the neck region, forelimb and limb joints also emitted fluorescence. Fluorescence in geckos is mostly bone-based (Sloggett 2018). On the dorsal side, the tip of the snout extending over the anterior portion of the rostrum ending between the two eyes was also blue (Fig. 2F). The only individual evaluated was a sub-adult. Here, some of the areas near the throat do not match with known bones and the fluorescence could be attributed to fluorescence in interstitial tissues (Taboada et al. 2017a).

Boiga cyanea (Duméril, Bibron & Duméril, 1854)

Boiga cyanea, the Green Cat Snake, is a long, slender snake with a large head. This species has a green dorsal colour in adults and rust coloured body with a green head in juveniles (Kabir et al. 2009). We found only one adult individual and exposed it to UV light. Under white light, the dorsal side of the head is green, but the upper labial scales showed a weak yellow colour. Under UV light, the neck and head region produced a bright orange fluorescence (Fig. 3). The fluorescence of the lateral side of the head was brighter than the dorsal side.

Discussion

We report, for the first time, biofluorescence in one species of frog and three species of reptiles in north-eastern Bangladesh. This is consistent with several studies documenting biofluorescence in terrestrial vertebrates (Taboada et al. 2017a, 2017b; Lamb and Davis 2020; Top et al. 2020). All species observed were nocturnal, thus making interpretation of these observations difficult. Many species of nocturnal amphibians and reptiles have developed adaptations to low light conditions (Taboada et al. 2017a; Mohun and Davies 2019).

It has been hypothesised that biofluorescence in animals could aid in visualising conspecifics or hetero-

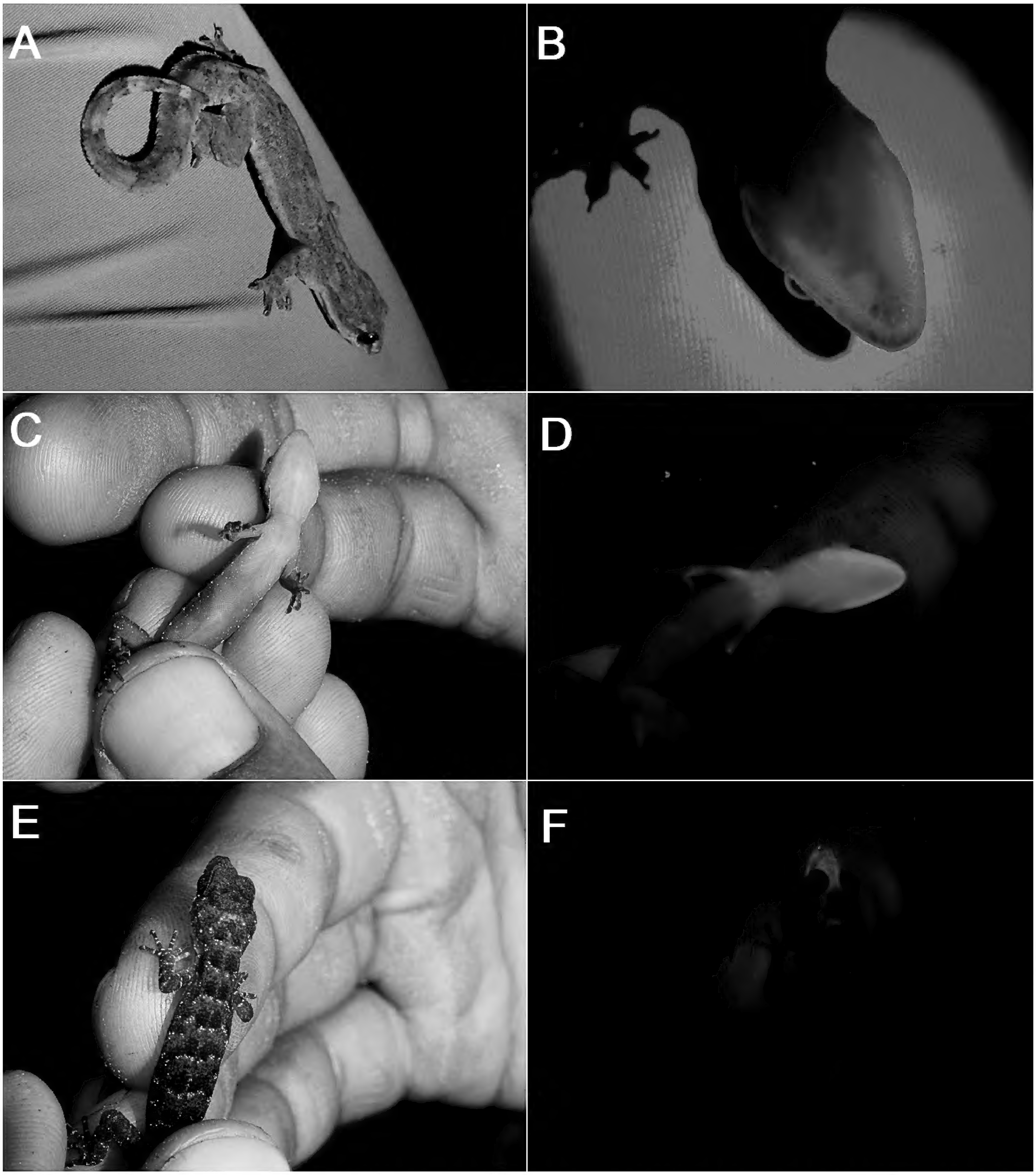

Figure 2. **A.** *Hemidactylus platyurus* in normal light. **B.** Lit portion of the ventral side of the head region under UV LED light in *H. platyurus*. **C–E.** Ventral and dorsal body portion of *Cyrtodactylus tripuraensis* in normal light. **D, E.** Showing fluorescence in jaw region and snout region under UV LED light and **F.** Showing fluorescence on the rostrum.

specifics under low light intensities (Taboada et al. 2017a; Lamb and Davis 2020). Typically, animals that are active at dawn, daytime or early twilight conditions are likely to be exposed to UV light or blue light spectra (Cramer et al. 2013). Thus, fluorescence at these hours could be advantageous in visualising individuals. The spectral irradiance of moonlight (ranging from 480–1000nm, Cramer et al. 2013) overlaps with the wavelengths necessary for biofluorescence (Taboada et al. 2017a; Prötzel et al. 2018; Lamb and Davis 2020). However, contributions of reflected UV light and fluoresced light may also vary considerably between species. For example, in Neotropical frogs, UV light re-emitted from frogs contributed between 18–28% of the total emitted light (Tadoba et al. 2017a, 2017b). In contrast, Pumpkin Toadlets (*Brachycephalus ephippium*) emitted only 3% of the total emitted light as biofluorescence (Nunes et al. 2021). Thus, a trade-off be-

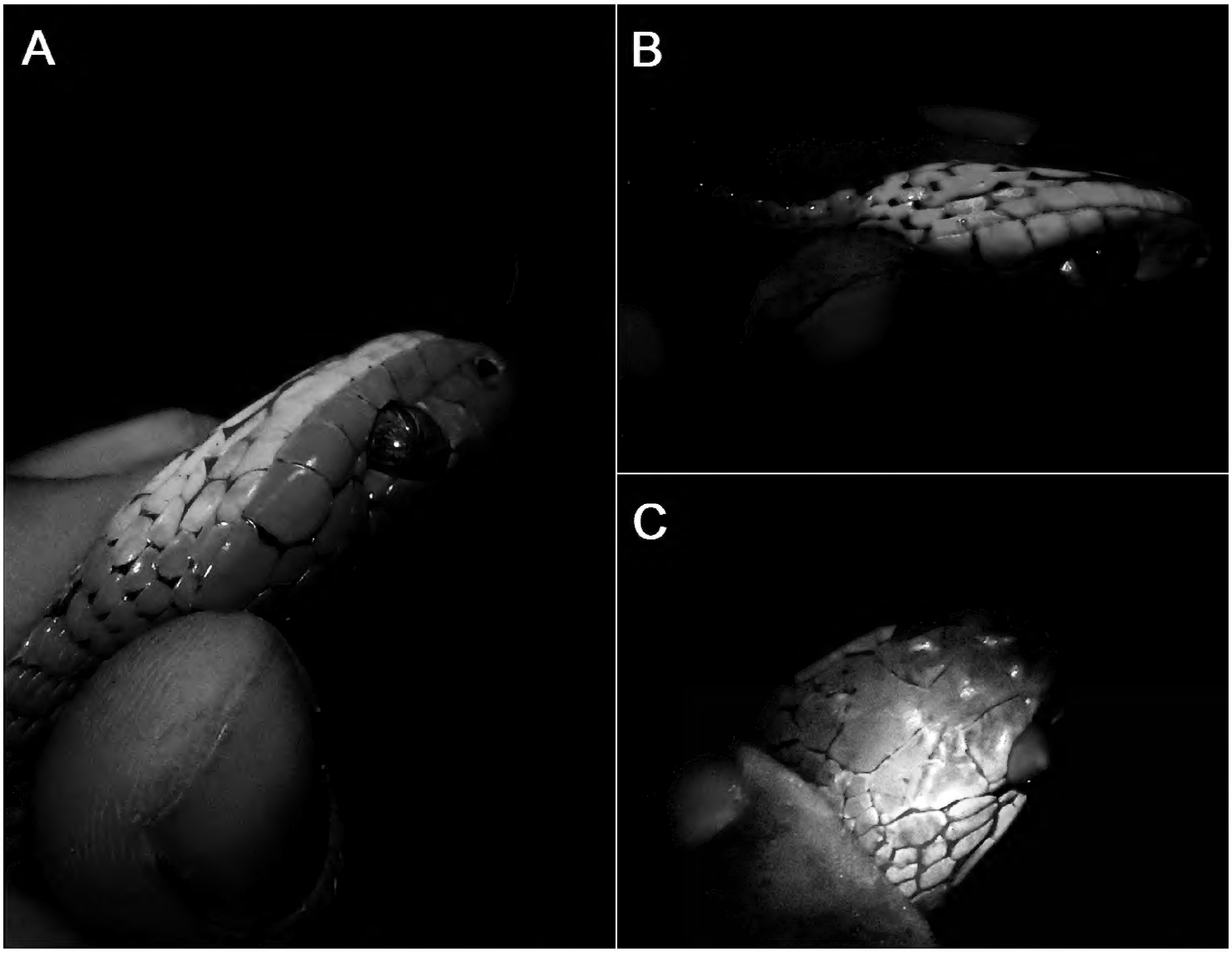

Figure 3. **A.** Head and neck region of *Boiga cyanea* under normal light. **B.** Lit portion of lateral side of the head under UV light. **C.** Dorsal portion of head showing fluorescence UV light.

tween biofluorescence and reflectance may determine the extent to which species may use biofluorescence to visualise individuals or perceive signals (Taboada et al. 2017a, 2017b; Lamb and Davis 2020). We speculate that the four species with biofluorescence in our study could utilise the low light conditions during moonlit nights (Cramer et al. 2013) to send signals to each other or recognise conspecifics (Taboada et al. 2017a, 2017b; Lamb and Davis 2020). Additional research is necessary to better characterise the extent of biofluorescence in amphibians and reptiles as well as to determine how this is used in these species.

We hope that our work will inspire further research on biofluorescence in amphibians and reptiles in Bangladesh and elsewhere.

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